APPARATUS AND METHOD OF PORTABLE AUTOMATED BIOMONITORING OF WATER QUALITY

This application claims the benefit of U.S. Provisional Application Ser. No. 60/444,202, filed Feb. 3, 2003, which is hereby incorporated by reference.

I. FIELD OF THE INVENTION

The present invention relates generally to an apparatus and method for monitoring water quality. More particularly, the present invention relates to a portable apparatus and method for monitoring water quality using the ventilatory behavior and body movement of aquatic organisms.

II. BACKGROUND OF THE INVENTION

Ventilatory responses are often some of the first prelethal symptoms exhibited by animals to environmental stressors. Continued, abnormal ventilatory behavior, such as rapid, shallow, or erratic breathing, can indicate physiological damage that may be irreversible. Changes in the ventilatory behavior of fish have been shown to be a reliable indicator of accidental toxic spills or "slugs" of pollutants in wastewater and drinking water systems. Accordingly, ventilatory biomonitoring systems can serve as an early indicator of impending damage to aquatic ecosystems and possible harm to humans.

The technological means are readily available to log and display ventilatory signals for subsequent analysis. As a result, there are a considerable number of studies that have examined ventilatory behavior of fish and other aquatic organisms. A large number of substances at lethal levels have been shown to elicit ventilatory responses relatively quickly. For many pollutants, a significant response was often generated in less than one hour of exposure to concentrations approaching the 96-hour LC50 (the concentration at which fifty percent of the organisms expire within 96 hours of exposure). Studies performed using subacutely toxic samples of effluents or individual pollutants (concentrations well below the reported LC50 concentration) often documented responses within one to ten hours of exposure.

Although a variety of organisms have been examined for this purpose, including crayfish, aquatic insect larvae, and bivalves, most research in aquatic ventilatory behavior has used freshwater fish species. This is largely because fish are generally more ecologically "visible" in their importance in aquatic systems and many species (particularly the salmonids and centrarchids) have large opercular flaps that yield relatively clear ventilatory signals for measurement and evaluation.

The ventilatory parameters in fish that have been shown to be affected by toxicity include ventilatory rate (opercular movement over time), depth of ventilation (amplitude), coughing or gill purge rate, and erratic episode frequency due to sudden movement of the organism. Most commonly, changes in just ventilatory rate, as opposed to the other parameters just mentioned, have been used as a bioindicator of toxic conditions. The depth of ventilation and gill purge or cough rate, however, have been reported to be more sensitive indicators of toxicity for some compounds.

Changes in ventilatory rate are often determined by manual examination of the peaks per unit area on a strip-chart recording. Depth of ventilation or signal amplitude is similarly measured from top to bottom of the waveform on the strip chart. Cough rate has been more difficult to determine even with manual examination of a strip chart as several different types of coughs may be present, with their own corresponding characteristic waveform pattern. Also, without the use of simultaneous video techniques, the actual occurrence of a cough is not always clear.

Another important aspect of water quality analysis is the ability to test water from a variety of sources at different locations. This is especially important when the water draining into a body of water comes from different sources. However, the nature and size of water monitoring equipment typically prevents such field testing.

III. SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a portable apparatus for automated biomonitoring of water quality.

Another object of the present invention is to be able to include behavioral parameters such as the depth of ventilation, cough rate, and whole body movement of an aquatic organism in addition to ventilatory frequency data in the portable automated biomonitoring of water quality.

A related object of the present invention is to be able to further include water quality characteristics such as dissolved oxygen, pH, temperature, and conductivity in the portable biomonitoring of water quality.

Another object of the present invention is to provide improved waveform processing of data signals from aquatic organisms to reduce spurious data signals.

Another object of the present invention is to provide a portable array of biomonitor exposure chambers with an integral water delivery and drain system for improved ventilatory signal data collection and biomonitoring operation.

Another object of the present invention is to provide a programmable alarm response that includes automated water sampling and optional remedial action such as isolation of a water pollution source.

Many of these objects are met by a portable system for monitoring and evaluating water quality including an exposure chamber for housing an aquatic organism and configured to contain water to be monitored, a water inlet for directing water to the exposure chamber, and electrodes for sensing electrical signals generated by the organism during ventilatory behavior and body movement in the water being monitored. The electrodes quantify the generated electrical signals into data and output the data as a behavioral signal. Electrical signals picked up and quantified by the electrodes may be supplied to an automatic controller, which determines a plurality of ventilatory and body movement parameters based on the signals from the electrodes. The controller compares the parameters with corresponding thresholds to determine when the water to which the organism is exposed has caused physiological stress to the organism. A recirculating apparatus recirculates water to the exposure chamber for further testing.

The system provides electrical signals to the controller or similar device for determining a wide variety of ventilatory and body movement parameters. In a preferred embodiment, the apparatus provides electrical signals for determining at least the ventilatory frequency, the average ventilatory depth, and the cough rate of the organism.

The system may further include various devices operative in response to a determination of a water quality problem by the controller. For example, it may include an alarm mechanism, which generates an alarm, a sample device which collects samples of the water being monitored for subse-